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(54) Method of digital recording

(57) A digital television receiver in the form of a set-top box includes a hard disk drive for storing a dynamic view buffer (34). Content from a live feed (40) is continuously stored in the buffer. The buffer can then be ac-

cessed at different points, thus allowing playback to be time-shifted. A cropping operation, whereby content is removed from the beginning (37) of the buffer is used to keep the size of the buffer in check. Cropped data can be used to create new record files.

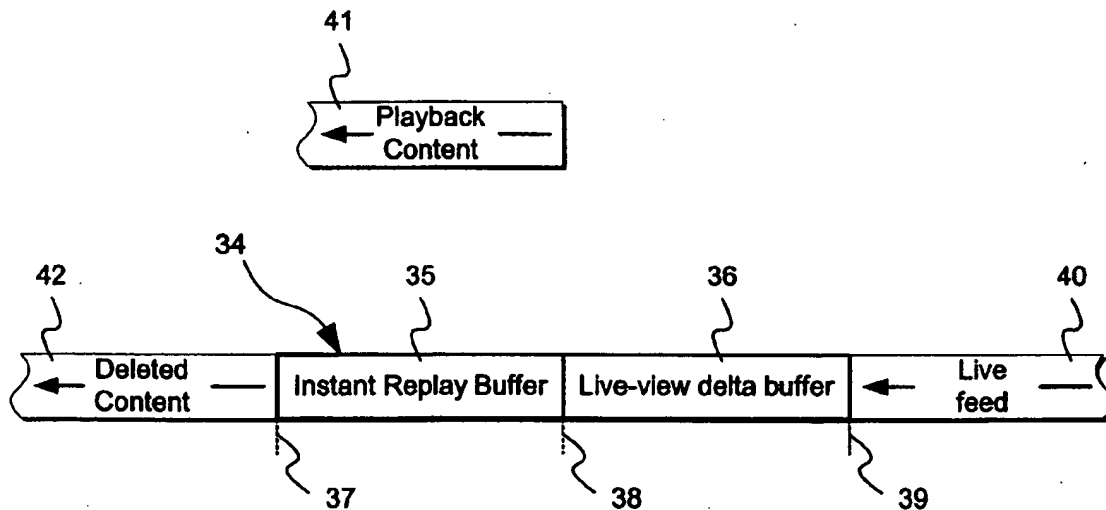


Fig. 4

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## Description

[0001] The present invention relates to a method of digital recording. In particular, it relates to a method of digital recording in digital television sets and digital television set-top boxes.

[0002] In digital television, television signals are broadcast in digital form through a terrestrial, cable or satellite network. Digital television has several advantages over longer-established analogue television. It permits transmission of higher resolution images with improved sound quality, while being bandwidth efficient.

[0003] A digital receiver is used to receive and decode digital television signals. The receiver can be integrated into a television set or, more usually, come in the form of a set-top box. If a so-called high definition television (HDTV) set is used, then the user can enjoy watching television programmes with a high resolution picture.

[0004] Digital television can also be used to provide enhanced services, such as on-screen shopping and internet access, and to give greater control to the user over the choice and presentation of broadcast content. For example, digital receivers can be used to record and playback programmes using an in-built hard disk drive. The user can pause, then resume playback and perform other operations similar to those found in existing video cassette recorders (VCRs) and digital versatile disc (DVD) recorders. An example of a digital receiver having an in-built hard disk is the Nokia™ Mediamaster DVB 9902 S.

[0005] A method of digital video recording and playback is described in US-A-5381551. In this system, a circular buffer stored on the disk drive is used to record audio and video programme signal data. Once the buffer is full, old data is overwritten with new data, starting at the beginning of the buffer. However, this system has the drawback that the size of the buffer is set to a predetermined size. This limits the amount of content that may be stored and, thus, the duration of pause.

[0006] The present invention seeks to provide an improved method of digital recording.

[0007] According to the present invention there is provided a method of digital recording comprising providing a playback file for storing a stream of data, defining, within said playback file, at least one section to be recorded, providing a record file comprising said at least one section and providing an updated playback file excluding said at least one section. This has the advantage that the size of the playback file is kept in check, without sacrificing data which a user wishes to record.

[0008] The providing of said updated playback data file may comprise excluding, from said updated playback file, at least one other section of said playback data file which is not comprised in said record file. This has the advantage that not only those sections which are to be recorded, but also those sections which are not to be recorded, are purged from the updated playback file.

[0009] The method may comprise defining, within

said playback file, at least two sections to be recorded thereby defining at least one section, between neighbouring ones of said at least two sections to be recorded, which is not comprised in said record file. The providing of said updated playback data file may comprise excluding said at least one section between each of said neighbouring ones of said at least two sections to be recorded, which is not comprised in said record file.

[0010] The providing of said playback file may include adding a stream of data to a first end of said playback file. The providing of said playback file may include cropping data from a second end of said buffer file. This has the advantage of keeping the size of the playback file in check.

[0011] The method may comprise suspending cropping before defining said at least one section to be recorded. This has the advantage that recordable data is not deleted prior to being recorded. The method may comprise resuming cropping after defining said at least one section to be recorded or after providing said record file comprising said at least one section. The method may comprise resuming cropping after adding said cropped section to said record file.

[0012] The providing of said record file may comprise said at least one section comprises providing a record file. The providing of said record file comprising said at least one section may comprise copying said at least one section from said playback file to said record file.

[0013] The providing of said updated playback file excluding said at least one section may comprise cropping said at least one section from said playback file. The providing said updated playback file excluding said at least one section may comprise cropping said at least one section from said playback file. The providing of said record file comprising said at least one section may comprise adding said at least one cropped section to said record file.

[0014] The method may further comprise cropping, from said playback file, at least one other section of said playback file which is not comprised in said record file. This has the advantage that not only those sections which are to be recorded, but also those sections which are not to be recorded are purged from the updated playback file.

[0015] The method may comprise defining, within said playback file, at least two sections to be recorded thereby defining at least one section, between neighbouring ones of said at least two sections to be recorded, which is not comprised in said record file. The method may comprise cropping from said playback file said at least one section between each of said neighbouring ones of said at least two sections to be recorded, which is not comprised in said record file.

[0016] The method may comprise providing a marker file for storing data relating to position, within said playback file, of said at least one section to be recorded. This has the advantage that data within the playback file is not overwritten with markers. Furthermore, the posi-

tion of said at least one section may be quickly found by searching the marker file rather than the playback file.

**[0017]** The marker file may comprise at least one pair of pointers, each pair of pointers for specifying a beginning and an end of a respective one of each of said at least one section.

**[0018]** Each pair of pointers may specify the beginning and end of each of a respective one of said at least one section relative to the first end of said playback file. This has the advantage that if data is cropped from the second end of said playback file, the position said at least one section is validly specified.

**[0019]** Each pair of pointers may specify the beginning and end of a respective one of said at least one section relative to the second end of said playback file and the method may further comprise updating said marker file following the cropping of data from said second end of said playback file.

**[0020]** The method may comprise receiving a stream of encoded data and storing said stream in said playback file. The stream of encoded data may be compressed. The stream of encoded data may be encoded according to an MPEG standard. The method may comprise retrieving a stream of encoded data from said updated playback file and decoding said stream. The method may comprise retrieving a stream of encoded data from said record file and decoding said stream.

**[0021]** According to the present invention there is provided a computer program for executing the method.

**[0022]** According to the present invention there is provided a computer program which, when loaded and executed by a digital recording device, causes said digital recording device to provide a playback file for storing a stream of data, to define, within said playback file, at least one section to be recorded, to provide a record file comprising said at least one section and to provide an updated playback file excluding said at least one section.

**[0023]** According to the present invention there is further provided a digital recording device comprising a storage medium, a supply of a stream of data, a processor, wherein said processor is configured to provide a playback file for storing said stream of data in said storage medium, to define, within said playback file, at least one section to be recorded; to provide a record file comprising said at least one section and to provide an updated playback file excluding said at least one section.

**[0024]** According to the present invention there is still further provided a digital television receiver including the digital recording device.

**[0025]** According to the present invention there is still further provided a digital television set including the digital recording device.

**[0026]** Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 shows a digital receiver and a television set;

Figure 2 is a schematic diagram of a digital receiver; Figure 3 shows a functional layer structure of a digital receiver shown in Figure 2;

Figure 4 shows a dynamic view buffer;

Figure 5 illustrates cropping a file;

Figure 6 illustrates cropping-to-file of a file;

Figure 7 illustrates truncating a file;

Figures 8a and 8b illustrate cropping using a FAT-based file system;

Figures 9a to 9h illustrate dynamic viewing;

Figures 10a to 10c illustrates channel swapping;

Figure 11 is a flow diagram of a method of digital recording;

Figures 12a to 12d show modification of a dynamic view buffer during recording;

Figure 13 shows a section record marker file;

Figure 14 is a flow diagram of a method of creating a recording file;

Figures 15a to 15g show creation of recording file;

Figure 16 is a flow diagram of another method of creating a recording file; and

Figures 17a to 17e show creation of recording file.

**[0027]** Referring to Figure 1, a user is provided with digital television service using a digital receiver 1 and a display device, such as a television set 2. The digital receiver 1 is in the form of a module, usually sold separately from the television set 2, which is commonly referred to as a "set-top box". The digital receiver 1, however, may be incorporated into the television set 2 and such television sets are usually referred to "integrated digital television sets". The television set 2 is capable of displaying high definition (HD) format images with a 16:9 aspect ratio and 1920×1080 pixels, although a television set capable of only displaying standard definition (SD) format images may also be used. A remote control unit 3 is provided for controlling the digital receiver 1 and, optionally, the television set 2.

**[0028]** A radio frequency (r.f.) signal carrying one or more digital television channels is transmitted by a broadcaster through a digital video broadcasting network comprising satellite, cable or terrestrial network (not shown) and is fed into the digital receiver 1. The digital receiver 1 processes the r.f. signal so as to provide video and audio signals for the television set 2. The user can select a channel and watch television programmes. As will be explained in more detail later, the digital receiver 1 provides dynamic viewing functionality which allows viewing to be paused, then resumed without loss programme content, replaying of content and fast-forwarding.

**[0029]** The digital receiver 1 will now be described in more detail:

Referring to Figure 2, the digital receiver 1 includes a port 4, a tuner 5, a demodulator 6, a demultiplexer

and decryptor unit 7 and a system bus 8. The demultiplexer and decryptor unit 7 is hereinafter referred to simply as the demultiplexer 7.

[0030] An r.f. signal (not shown) carrying one or more channels is received from the digital video broadcasting network (not shown) and fed via the port 4 into the tuner 5. The tuner 5 isolates a channel and produces a baseband signal. The baseband signal is fed into the demodulator 6 which produces a digital bit-stream comprising data packets. The bit-stream is passed into the demultiplexer 7 which sorts the data packets according to programme and produces a transport stream which is placed on the system bus 8.

[0031] The digital receiver 1 includes a central processing unit (CPU) 9, memory, in the form of dynamic random access memory (DRAM) 10, static random access memory (SRAM) 11, electrically erasable and programmable read-only memory (EEPROM) 12 and flash memory 13, and storage 14, in the form of a hard disk drive. In this case, the hard disk 14 has a capacity of 40 GB. The digital receiver 1 further includes an infrared receiver 15 for receiving signals from the remote control 3 (Figure 1) and a smart card reader 16 for receiving a smart card (not shown) holding data needed by the demultiplexer 7 for decrypting signals.

[0032] The digital receiver 1 includes a transport stream parser 17, a video decoder 18, a subtitle decoder 19 and an audio decoder 20, a graphics processor 21 and an audio processor 22.

[0033] The digital receiver 1 also includes several interfaces including a SCART connector 22 for providing video and audio signals to the television set 2, an audio connector 23 for providing audio-only signals to audio equipment (not shown), a serial port 24 and a return channel port 25 for connection to a modem (not shown). Additional ports may also be provided such as an auxiliary SCART connector for providing signals to a video cassette recorder (not shown) or a Universal Serial Bus (USB) connector.

[0034] The transport stream, which is fully or partially encoded, preferably according to the MPEG-2 standard, is directed to the hard disk 14 for storage or to the transport stream parser 17. The transport stream parser 17 processes the transport stream, which comprises data packets, and determines to which decoder 18, 19, 20 to send data packets. The decoders 18, 19, 20 decode and decompress the data packets and pass them on to the processors 21, 22 for further processing. Signals from the video and audio processors 21, 22 are fed to the SCART and audio connectors 23, 24 for transmission to the television set 2 (Figure 1) and, optionally, speakers (not shown).

[0035] The CPU 9 controls operation of the digital receiver 1. When the digital receiver 1 is switched on, the CPU 9 loads and runs an operating system from EEPROM 12.

[0036] The operating system includes device drivers

to control hardware devices such as the hard disk 14. Instructions as to how the digital receiver 1 should operate are received from an application run by the CPU 9, loaded from the EEPROM 12, the flash memory 13 or the hard disk 14. In this example, applications are not platform specific. Therefore, additional software, often referred to as "middleware", is used to help applications and the operating system communicate.

[0037] Referring to Figure 3, a functional layer structure of the digital receiver 1 comprises digital receiver hardware 27, an operating system 28, middleware layer 29 and an applications layer 30. It will be appreciated that the middleware layer 29 and the operating system layer 28 may be combined.

[0038] As will be described in more detail later, the middleware layer 29 includes a dynamic view buffer engine 31 and a record engine 32 which are used control dynamic viewing by creating and managing files on the hard disk 14 and a playback engine 33 which is used to read files and transmit transport stream to the transport stream parser 17.

#### *Dynamic viewing*

[0039] Dynamic viewing refers to a method of viewing television. Content from a live feed, in this case transport stream, is continuously stored in a buffer held on the hard disk 14. The buffer can then be accessed at different points thus allowing playback to be time-shifted.

[0040] If the user simply wishes to watch the live feed, then content is read from the buffer as soon as it is stored. If the user suspends viewing, content continues to be stored in the buffer. This allows the user to resume viewing at a later time from the point viewing was suspended.

[0041] Content is not immediately erased when it is played back. This allows the user to replay content. However, a consequence of this is that the buffer will continue to grow unchecked. Thus, it is advantageous to manage the buffer so as to prevent this from happening unnecessarily.

#### *Dynamic view buffer*

[0042] Referring to Figure 4, a playback file, hereinafter referred to as a dynamic view buffer 34, is stored on the hard disk 14. The dynamic view buffer 34 comprises first and second parts 35, 36, a beginning 37, an intermediate point 38 and an end 39.

[0043] Transport stream 40 comprising live feed is received from the demultiplexer 7 via the system bus 8 and is added to the second part 36 of the dynamic view buffer 34 at the end 39 of the buffer 34. Because of this, the second part 36 of the buffer 34 is referred to as the "live-view delta buffer" while the end 39 of the buffer 34 is referred to as the "live position".

[0044] Data 41 is taken from the intermediate point 38 of the buffer 34 for playback. Because of this, the inter-

mediate point 38 is referred to as the "view position". The first part 35 of the buffer 34 is known as the "instant replay buffer" and comprises content preceding the view position 38 which may, although not necessarily, have been watched by the user.

[0045] As will be explained in more detail later, as the stream of data 40 is fed into the end 39 of the buffer 34, the buffer 34 grows. If playback is paused, then the live-view delta buffer 36 grows, while the instant replay buffer 35 remains the same. If playback occurs, then the view position 38 shifts. Content which was once part of the live-view delta buffer 36 becomes part of the instant replay buffer 35. Thus, the live-view delta buffer 36 remains constant in size, while the instant replay buffer 35 grows. In either case, the size of the dynamic viewing buffer 34, and in particular the instant replay buffer 36, may be kept in check by deleting content 42 from the beginning 37 of the dynamic viewing buffer 34.

#### *File operation*

[0046] To manage the dynamic view buffer 34 and other files held on the hard disk 14, the record engine 31, the dynamic view buffer engine 32 and the playback engine 33 use file operations including crop, crop-to-file and truncate, which will now be described in more detail:

Referring to Figures 5a and 5b, a crop operation, **Crop()**, removes from the beginning of a file 43, a portion of data 44 thus leaving a cropped file 43'. The crop function is used to prevent the dynamic view buffer 34 from growing too large. The removed data portion 44 is lost.

Referring to Figures 6a and 6b, a crop-to-file operation, **Crop\_to\_file()**, not only crops the file 43 as described earlier, but stores the removed data portion 44 as a new file 44'.

Referring to Figure 7a and 7b, a truncate operation, **Truncate()**, removes from the end of a file 43, a portion of data 45 thus leaving a truncated file 43'.

[0047] Other conventional file operations such as copy, **Copy()**, are also used.

#### *Crop implementation using FAT-based file system*

[0048] In File Allocation Table (FAT)-based systems, implementation of a crop function is straightforward. Table entries of a FAT have a one-to-one correspondence to clusters of a hard disk. Each table entry is a pointer to another entry in the table. Thus, clusters in a file are represented by pointing to the first cluster of the file. The rest of the clusters are linked using FAT entries pointing to the next entry.

[0049] Thus, to implement a simple crop function, **Crop()**, a pointer to the first cluster is set to point to a

cluster further down the linked list. Simple cropping is carried out in units of clusters.

[0050] Referring to Figures 8a, a FAT 46 comprises first, second, third, fourth, fifth, sixth and seventh entries 47<sub>1</sub>, 47<sub>2</sub>, 47<sub>3</sub>, 47<sub>4</sub>, 47<sub>5</sub>, 47<sub>6</sub>, 47<sub>7</sub>. Each table entry 47<sub>1</sub>, 47<sub>2</sub>, 47<sub>3</sub>, 47<sub>4</sub>, 47<sub>5</sub>, 47<sub>6</sub>, 47<sub>7</sub> includes a pointer to another table entry 47<sub>1</sub>, 47<sub>2</sub>, 47<sub>3</sub>, 47<sub>4</sub>, 47<sub>5</sub>, 47<sub>6</sub>, 47<sub>7</sub> or a null value. For example, the first entry 47<sub>1</sub> includes a pointer to the second entry 47<sub>2</sub>. The second entry 47<sub>2</sub> includes a pointer to the fourth entry 47<sub>4</sub>.

[0051] A file system 48 includes a file directory 49 and first, second and third files 50<sub>1</sub>, 50<sub>2</sub>, 50<sub>3</sub>. The first file 50<sub>1</sub> comprises clusters corresponding to first, second, fourth, sixth and seventh entries 47<sub>1</sub>, 47<sub>2</sub>, 47<sub>4</sub>, 47<sub>6</sub>, 47<sub>7</sub>. The second file 50<sub>2</sub> comprises a cluster corresponding to the third entry 47<sub>3</sub>. The third file 50<sub>3</sub> comprises a cluster corresponding to the fifth entry 47<sub>5</sub>.

[0052] Referring to Figure 8b, the first file 51<sub>1</sub> is cropped by pointing to the second entry 47<sub>2</sub>, thereby removing the cluster corresponding to the first entry 47<sub>1</sub>.

[0053] The simple crop may be refined to allow smaller units of data to be cropped. A header is included in each cluster containing information relating to the starting position of blocks of data. Thus, smaller units of data may be "skipped".

#### *Dynamic Viewing*

[0054] The dynamic view buffer engine 32 (Figure 3) is used to create a dynamic view buffer 34 for each channel viewed. The playback engine 33 controls retrieval of content 41 (Figure 4) for supply to the transport stream parser 17 and cropping of the dynamic view buffer 34.

#### Creating a dynamic view buffer

[0055] Referring to Figure 9a, when a user selects a channel, a dynamic view buffer 34 is created on the hard disk 14 into which live feed 40 (Figure 4) is fed. Thus, the live-view delta buffer 36 begins to grow, as indicated by arrow 'A'. A first amount of content 40', placed at the beginning of the dynamic view buffer 34, is shown as a shaded portion in Figure 9a. Playback is preferably initiated as soon as possible to minimize lag  $\Delta$  between the live position 39 and view position 38. This point in time may be labelled time  $t_0$ .

#### Playback

[0056] Referring to Figure 9b, as the user watches television, the view position 38 moves along the dynamic view buffer 34 and content 41 (Figure 4) is read out. Thus, the instant replay buffer 35 grows, as indicated by arrow 'B', until, at a time  $t_1 > t_0$ , it reaches a predetermined size  $\Sigma$ , which may be set by the user or the receiver 1. The live-view delta buffer 36 remains the same size, namely  $\Delta$ . Thereafter, the dynamic view buffer 34 is cropped to maintain the size of the instant replay buffer

er 35.

[0057] Referring to Figure 9c, the size of the instant replay buffer 35 is maintained by cropping the dynamic view buffer 34, as shown by arrow 'C', at the same rate as data 41 for viewing is read. Thus, as live feed is fed into the end 39 of the dynamic view buffer 34, content is deleted from the beginning 37. Consequently, the content 40' at the beginning of the dynamic view buffer 34 is eventually erased.

#### Live pause

[0058] Referring to Figure 9d, the user pauses live playback using the remote control 3 (Figure 1). The view position 38 is held and cropping is suspended. However, live feed continues to be supplied into the end 39 of the dynamic view buffer 34. Thus, the live-view delta buffer 36 and the lag  $\Delta$  begin to grow. At time  $t_3$ , the live-view delta buffer 36 has grown to  $\Delta'$ , where  $\Delta' > \Delta$ .

#### Resuming playback

[0059] Referring to Figure 9e, the user resumes playback using the remote control 3 (Figure 1). Live feed continues to be supplied to the end 39 of the dynamic view buffer 34, as shown by arrow 'A', read-out of content and transfer of data from the live-view delta buffer 36 to the instant replay buffer 35 resumes, as shown by arrow 'B' and cropping of the dynamic view buffer 34 is also resumed, as indicated by arrow 'C'.

#### Replay

[0060] Referring to Figure 9f, the user can replay content using the remote control 3 (Figure 1). The view position 38 jumps back a predetermined number of bytes to a back view position 38'. Playback thereafter continues.

[0061] Referring to Figure 9g, if the jump back causes the instant replay buffer 35 to have a size  $\Sigma'$ , such that  $\Sigma' < \Sigma$ , then cropping is suspended during playback, until it reaches the predetermined limit  $\Sigma$ .

#### Fast forward

[0062] Referring to Figure 9h, the user can also jump forward. The back view position 38' jumps forward a predetermined number of bytes to a forward view position 38". Playback thereafter continues. The size of the instant replay buffer 35 may also be adjusted to the predetermined limit  $\Sigma$ .

#### Changing channel

[0063] Referring to Figure 10a, an existing dynamic view buffer 34<sub>1</sub> is maintained while the user watches a channel, in this case Channel X, in a manner hereinbefore described.

[0064] Referring to Figure 10b, if a user changes channel, to Channel Y, live feed to the existing dynamic view buffer 34<sub>1</sub> is suspended, a new dynamic view buffer 34<sub>2</sub> is created and live feed is fed to the new dynamic view buffer 34<sub>2</sub>.

[0065] Referring to Figure 10c, the existing dynamic view buffer 34<sub>1</sub> is erased, thus leaving the new dynamic view buffer 34<sub>2</sub>.

#### Recording

[0066] A process by which a user can record content for later viewing will now be described:

Referring to Figures 11 and 12a, a dynamic view buffer 34 is created and content played back in a manner hereinbefore described (step S1)

Referring now to Figures 11 and 12b, the user instructs the digital receiver 1 that he wishes to record a program. The digital receiver 1 responds by initiating recording (step S2). This comprises disabling cropping to prevent erasure of potentially wanted content. Thus, the dynamic view buffer includes a temporary instant replay buffer portion 35a at the beginning of the dynamic view buffer 34.

Referring now to Figures 11 and 12c, the user identifies sections that they wish to record 51<sub>1</sub>, 51<sub>2</sub> (step S3). A start 52<sub>1</sub>, 52<sub>2</sub> and end 53<sub>1</sub>, 53<sub>2</sub> of each section 51<sub>1</sub>, 51<sub>2</sub> to be recorded is marked. This may be done by the user viewing the content of the dynamic view buffer 34 at a normal or accelerated rate, optionally pausing playback, and instructing the digital receiver 1 to put down a `record_start` or `record_end` mark. The marks are stored as meta-data in either a separate file on the hard disk 14 or in flash memory 13. As a result of the user's selection, one or more sections 54<sub>1</sub>, 54<sub>2</sub>, 54<sub>3</sub> of the dynamic view buffer 34 are not selected to be recorded. Marking is described in more detail later.

Referring now to Figures 11 and 12d, the user instructs the digital receiver 1 that they have finished marking-up sections 51 (step S4). Each section 51 is recorded to a file 55 using crop, crop-to-file and/or copy. A truncate operation may also be used. The temporary instant replay buffer portion 35a is deleted by purging the dynamic view buffer 34 of one or more complete or partial selected sections 51 and one or more complete or partial unwanted sections 54.

[0067] Playback is then resumed and cropping is re-enabled.

### Recording - Section record marker file

[0068] The process at steps S2 and 3 will now be described in more detail:

Referring to Figures 11, 12c and 13, when a recording is initiated, a section record marker file 56 is created on the hard disk 14 or in memory, such as DRAM 10 or flash memory 13.

[0069] The start 52<sub>1</sub>, 52<sub>2</sub> and end 53<sub>1</sub>, 53<sub>2</sub> of each section 51<sub>1</sub>, 51<sub>2</sub> are recorded in the recorder marker file 56 as record\_start 57<sub>1</sub>, 57<sub>2</sub> and record\_end 58<sub>1</sub>, 58<sub>2</sub> marks respectively. Preferably, the marks 57, 58 are recorded in the file 56 in the order that the start and ends 57, 58 of the sections 51 which they represent appear in the dynamic view buffer 34. Each mark 57, 58 comprises meta-data pointing to a position 57, 58 within the dynamic view buffer 34. Preferably, the meta-data point to the positions 57, 58 relative to end 39 of the dynamic view buffer 34. However, the meta-data may point to the positions 57, 58 relative to beginning 37 of the dynamic view buffer 34, provided pointers are updated whenever a crop or crop-to-file operation is performed resulting in a change of the position of the start 37 of the dynamic view buffer 34.

[0070] Two examples of the process-at step S4 will now be described in more detail:

### Recording - Section recording and dynamic view buffer purging - Example 1

[0071] Referring to Figures 14 and 15a, the dynamic view buffer engine 32 (Figure 3) checks whether there is a record\_start marker 57 in the section record marker file 56 (step S4.1.1). If a record\_start marker 57<sub>1</sub> is found, then it retrieves the record\_start marker 57<sub>1</sub> which points to the record\_start 52<sub>1</sub> (step S4.1.2). The dynamic view buffer engine 32 checks whether the record\_start 52<sub>1</sub> precedes the beginning of instant replay buffer 35 (step S4.1.3). If so, a part 54<sub>1</sub> preceding the record\_start 52<sub>1</sub> is cropped (step S4.1.4).

[0072] Referring to Figure 15b, the dynamic view buffer engine 32 then retrieves the record\_end marker 58<sub>1</sub> (step S4.1.5). It checks whether the record\_end 53<sub>1</sub> precedes the beginning of the instant replay buffer 35 (step S4.1.6). If so, the section 51<sub>1</sub> found between the record\_start 52<sub>1</sub> and record\_end 53<sub>1</sub> is copied to the record file 55, which is created at step S2 (step S4.1.7).

[0073] Referring to Figure 15c, the section 51<sub>1</sub> is cropped from the dynamic view buffer 34 (step S4.1.8).

[0074] The process returns to step S4.1.1, searching the dynamic view buffer 34 for the next section 51<sub>2</sub> to record.

[0075] Referring to Figure 15d, if the process finds another record\_start marker 52<sub>2</sub> at step S4.1.1 and it is determined at steps S4.1.2 and S4.1.3 that the record\_start 52<sub>2</sub> precedes the beginning of instant re-

play buffer 35, then a part 54<sub>2</sub> preceding the record\_start marker 52<sub>2</sub> is also cropped at step S4.1.4.

[0076] The second section 51<sub>2</sub> overlaps with the instant replay buffer 35. In this case, the process branches at step S4.1.6.

[0077] Referring to Figure 15e, a portion 51<sub>2A</sub> between record\_start 52<sub>1</sub> and the beginning of the instant replay buffer 35 is copied to the start of the record file 55 (step S4.1.9).

[0078] Referring to Figure 15f, the section 51<sub>2A</sub> is cropped from the dynamic view buffer 34 (step S4.1.10).

[0079] Up until now, the process has copied and cropped sections of the dynamic view buffer 34. Thus, the process has been operating in "copy-and-crop mode". However, once the process enters the instant replay buffer 35, it begins to copy sections to the record file 55. Consequently, the process switches to "copy only mode".

[0080] The process sets a copy\_start marker (not shown) to the beginning of the instant replay buffer 35 (step S4.1.11) and sets a copy\_end marker (not shown) to the record\_end 53<sub>2</sub> (step S4.1.12). The copy\_start and copy\_end markers are preferably stored in cache memory (not shown) in the CPU 9 or in other memory, such as DRAM 10.

[0081] Referring to Figure 15g, a portion 51<sub>2B</sub> found between the beginning of the instant replay buffer 35 and the record\_end 53<sub>2</sub> is copied to the beginning of the record file 55 (step S4.1.13). Cropping is not used so as to preserve the instant replay buffer 35 intact.

[0082] The process then checks whether there are any further record\_start marks 57 left in the section record marker file 56 (Figure 13) (step S4.1.14). If no other record\_start mark 57 is found, as in this case, then the process ends. Otherwise, the process retrieves the record\_start marker 57 which points to a record\_start 52 (step S4.1.15) and sets a copy\_start marker (not shown) to the record\_start 52 (step S4.1.16). It then retrieves the record\_end marker 58 (step S4.1.17). The process returns to step S4.1.12, where a copy\_end marker (not shown) is set to the record\_end 53, following which the section is copied to the beginning of the record file 55 at step S4.1.13.

[0083] The dynamic viewing buffer 34 and record file 55 is shown in Figure 12d. A file footer may be optionally added.

### Recording - Section recording and dynamic view buffer purging - Example 2

[0084] Referring to Figures 16 and 17a, the dynamic view buffer engine 32 (Figure 3) checks whether there is record\_start marker 57 in the section record marker file 56 (step S4.2.1). If a record\_start marker 57<sub>1</sub> is found, then it retrieves the record\_start marker 57<sub>1</sub> which points to the record\_start 52<sub>1</sub> (step S4.2.2). The dynamic view buffer engine 32 checks whether the record\_start 52<sub>1</sub> precedes the beginning of instant re-

play buffer 35 (step S4.2.3). If so, a part 54<sub>1</sub> preceding the record\_start 52<sub>1</sub> is cropped (step S4.2.4).

[0085] Referring to Figure 17b, the dynamic view buffer engine 32 then retrieves the record\_end marker 58<sub>1</sub> (step S4.2.5). It checks whether the record\_end 53<sub>1</sub> precedes the beginning of the instant replay buffer 35 (step S4.2.6). If so, the section 51<sub>1</sub> found between the record\_start 52<sub>1</sub> and record\_end 53<sub>1</sub> is cropped to the record file 55 (step S4.2.7).

[0086] The process returns to step S4.2.1, searching the dynamic view buffer 34 for the next sections 51<sub>2</sub> to record.

[0087] Referring to Figure 17c, if the process finds another record\_start marker 52<sub>2</sub> at step S4.2.1 and it is determined at steps S4.2.2 and S4.2.3 that the record\_start 52<sub>2</sub> precedes the beginning of instant replay buffer 35, then a part 54<sub>2</sub> preceding the record\_start marker 52<sub>2</sub> is also cropped at step S4.2.4.

[0088] The second section 51<sub>2</sub> overlaps with the instant replay buffer 35. In this case, the process branches at step S4.2.6.

[0089] Referring to Figure 17d, a portion 51<sub>2A</sub> between record\_start 52<sub>1</sub> and the beginning of the instant replay buffer 35 is cropped and added to the start of the record file 55 (step S4.2.8).

[0090] Up until now, the process has cropped or cropped-to-file sections of the dynamic view buffer 34. Thus, the process has been operating in "crop mode". However, once the process enters the instant replay buffer 35, it begins to copy sections to the record file 55. Consequently, the process switches to "copy mode".

[0091] The process sets a copy\_start marker (not shown) to the beginning of the instant replay buffer 35 (step S4.2.9) and sets a copy\_end marker (not shown) to the record\_end 53<sub>2</sub> (step S4.2.10). The copy\_start and copy\_end markers are preferably stored in cache memory (not shown) in the CPU 9 or in other memory, such as DRAM 10.

[0092] Referring to Figure 17e, a portion 51<sub>2B</sub> found between the beginning of the instant replay buffer 35 and the record\_end 53<sub>2</sub> is copied to the beginning of the record file 55 (step S4.2.11). Cropping is not used so as to preserve the instant replay buffer 35 intact.

[0093] The process then checks whether there are any further record\_start marks 57 left in the section record marker file 56 (Figure 13) (step S4.2.12). If no other record\_start mark 57 is found, as in this case, then the process ends. Otherwise, the process retrieves the record\_start marker 57 which points to a record\_start 52 (step S4.2.13) and sets a copy\_start marker (not shown) to the record\_start 52 (step S4.2.14). It then retrieves the record\_end marker 58 (step S4.2.15). The process returns to step S4.2.10, where a copy\_end marker (not shown) is set to the record\_end 53, following which the section is copied to the beginning of the record file 55 at step S4.2.11.

[0094] The dynamic viewing buffer 34 and record file 55 is shown in Figure 12d. A file footer may be optionally

added.

[0095] In these examples, the recording process creates a new record file. However, it will be appreciated that an existing record file may be used. It will also be appreciated that multiple record files may be used. Thus, one record file may be used to record sports programmes, while another record file may be used to record current affairs programmes.

[0096] In this way, the size of the playback file is kept in check, without sacrificing content which the user may wish to record.

[0097] Dynamic viewing has several advantages. The same buffer is used for viewing of live and buffered content. This simplifies switching between live and buffered content and can also make it quicker and less prone to visual glitches.

[0098] It will be appreciated that many modifications may be made to the embodiment described above. For example, the storage may comprise a random-access memory and may include a magnetic, electric or optical storage medium. A non-volatile solid-state memory, for example a semiconductor memory, can be used instead of a hard disk to store the dynamic view buffer. Data need not be compressed before being written to the dynamic view buffer.

## Claims

1. A method of digital recording comprising:

providing a playback file (34) for storing a stream of data (40);  
defining, within said playback file, at least one section (51<sub>1</sub>) to be recorded;  
providing a record file (55) comprising said at least one section; and  
providing an updated playback file (34) excluding said at least one section.

2. A method according to claim 1, wherein said providing said updated playback file (34) comprises excluding, from said updated playback file, at least one other section (54<sub>1</sub>) of said playback data file which is not comprised in said record file.

3. A method according to claim 2, comprising defining, within said playback file (34), at least two sections (51<sub>1</sub>, 51<sub>2</sub>) to be recorded thereby defining at least one section (54<sub>2</sub>), between neighbouring ones of said at least two sections (51<sub>1</sub>, 51<sub>2</sub>) to be recorded, which is not comprised in said record file (55).

4. A method according to claim 3, wherein said providing said updated playback file (34) comprises excluding said at least one section (54<sub>2</sub>) between each of said neighbouring ones of said at least two sections (51<sub>1</sub>, 51<sub>2</sub>) to be recorded, which is not com-

- prised in said record file (55).
5. A method according to claim 1, wherein said providing said record file (55) comprising said at least one section (51<sub>1</sub>) comprises providing a record file initially without said at least one section.
  6. A method according to claim 5, wherein said providing said record file (55) comprising said at least one section (51<sub>1</sub>) comprises copying said at least one section from said playback file (34) to said record file.
  7. A method according to claim 1, wherein said providing said updated playback file (34) excluding said at least one section (51<sub>1</sub>) comprises cropping said at least one section from said playback file (34).
  8. A method according to claim 5, wherein said providing said updated playback file (34) excluding said at least one section (51<sub>1</sub>) comprises cropping said at least one section from said playback file (34).
  9. A method according to claim 8, wherein said providing said record file (55) comprising said at least one section (51<sub>1</sub>) comprises adding said at least one cropped section to said record file.
  10. A method according to claim 1, further comprising cropping, from said playback file (34), at least one other section (54<sub>1</sub>) of said playback file which is not comprised in said record file.
  11. A method according to claim 10, comprising defining, within said playback file (34), at least two sections (51<sub>1</sub>, 51<sub>2</sub>) to be recorded thereby defining at least one section (54<sub>2</sub>), between neighbouring ones of said at least two sections to be recorded, which is not comprised in said record file (55).
  12. A method according to claim 11, comprising cropping from said playback file (34) said at least one section (54<sub>2</sub>) between each of said neighbouring ones of said at least two sections (51<sub>1</sub>, 51<sub>2</sub>) to be recorded, which is not comprised in said record file.
  13. A method according to any preceding claim, wherein said providing said playback file (34) includes adding a stream of data (40) to a first end (39) of said playback file.
  14. A method according to claim 13, wherein said providing said playback file (34) includes cropping data from a second end (37) of said playback file.
  15. A method according to claim 14, comprising suspending cropping before defining said at least one section (51<sub>1</sub>) to be recorded.
  16. A method according to claim 15, comprising resuming cropping after defining said at least one section (51<sub>1</sub>) to be recorded.
  17. A method according to claim 15 or 16, comprising resuming cropping after providing said record file (55) comprising said at least one section (51<sub>1</sub>).
  18. A method according to any one of claims 15 to 17, comprising resuming cropping after adding said cropped section (51<sub>1</sub>) to said record file (55).
  19. A method according to any preceding claim, comprising providing a marker file (56) for storing data relating to position, within said playback file (34), of said at least one section (51<sub>1</sub>) to be recorded.
  20. A method according to claim 19, wherein said marker file (56) comprises at least one pair of pointers (57<sub>1</sub>, 58<sub>1</sub>), each pair of pointers for specifying a beginning (52<sub>1</sub>) and an end (53<sub>1</sub>) of a respective one of said at least one section (51<sub>1</sub>).
  21. A method according to claim 19, wherein said providing said playback file (34) includes adding a stream of data (40) to a first end (39) of said playback file and cropping data from a second end (37) of said playback file.
  22. A method according to claim 21, wherein each pair of said pointers (57<sub>1</sub>, 58<sub>1</sub>) specify the beginning (52<sub>1</sub>) and end (53<sub>1</sub>) of a respective one of said at least one section relative to the first end (39) of said playback file (34).
  23. A method according to claim 21, wherein each pair of said pointers (57<sub>1</sub>, 58<sub>1</sub>) specify the beginning (52<sub>1</sub>) and end (53<sub>1</sub>) of a respective one of said at least one section relative to the second end (37) of said playback file (34).
  24. A method according to claim 23, further comprising updating said marker file (56) following cropping of data from said second end (39) of said playback file (34).
  25. A method according to any preceding claim, comprising receiving a stream of encoded data (40) and storing said stream in said playback file (34).
  26. A method according to claim 25, wherein said stream of encoded data (40) is compressed.
  27. A method according to claim 26, wherein said stream of encoded data (40) is encoded according to an MPEG standard.
  28. A method according to claim 27, comprising retrieval-

ing a stream of encoded data (41) from said updated playback file (34).

29. A method according to claim 28, comprising decoding said stream of encoded data (41) retrieved from said updated playback file (34). 5
30. A method according to claim 27, comprising retrieving a stream of encoded data from said record file (55). 10
31. A method according to claim 30, comprising decoding said stream of encoded data retrieved from said record file (50). 15
32. A computer program for executing a method according to any preceding claim.
33. A computer program which, when loaded and executed by a digital recording device, causes said digital recording device: 20
  - to provide a playback file (34) for storing a stream of data (40);
  - to define, within said playback file, at least one section (51<sub>1</sub>) to be recorded; 25
  - to provide a record file (55) comprising said at least one section; and
  - to provide an updated playback file (34) excluding said at least one section. 30
34. A digital recording device comprising:
  - a storage medium (18);
  - a processor (9); 35
 wherein said processor is configured to provide a playback file (34) for storing a stream of data (40) in said storage medium; to define, within said playback file, at least one section (51<sub>1</sub>) to be recorded; to provide a record file (55) comprising said at least one section and to provide an updated playback file excluding said at least one section. 40
35. A digital television receiver (1) including the digital recording device according to claim 34. 45
36. A digital television set (2) including a digital recording device according to claim 34. 50

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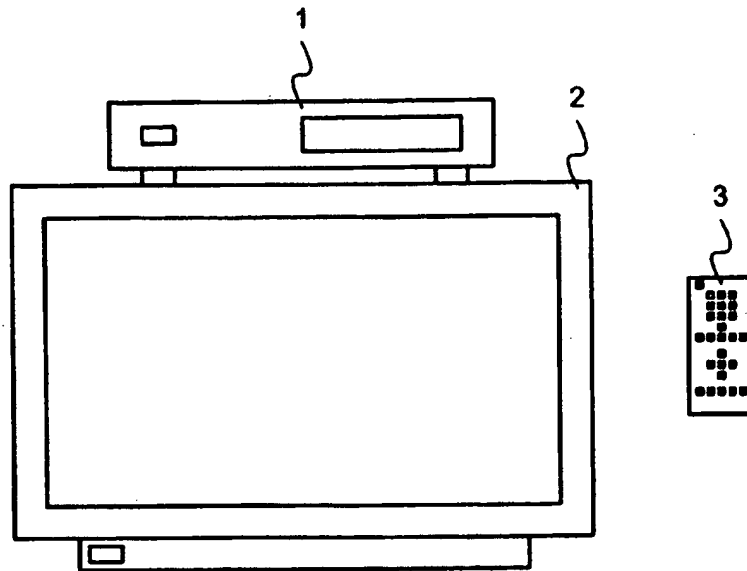


Fig. 1

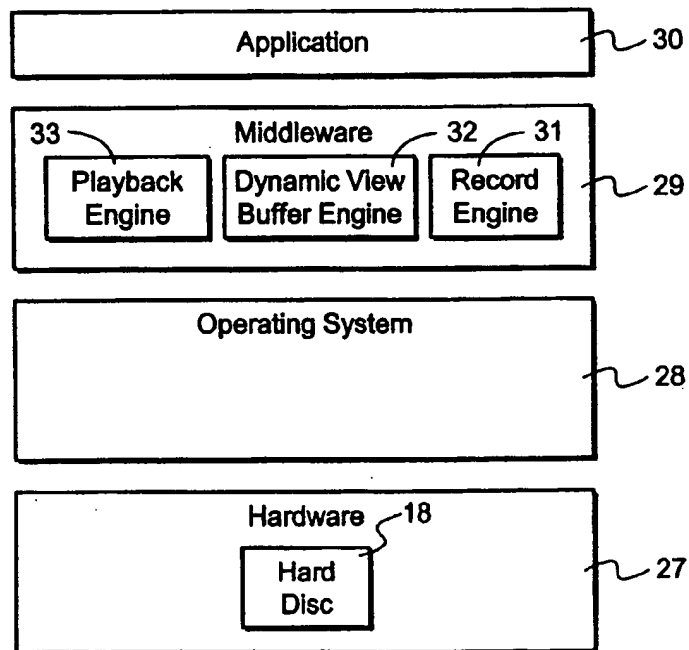
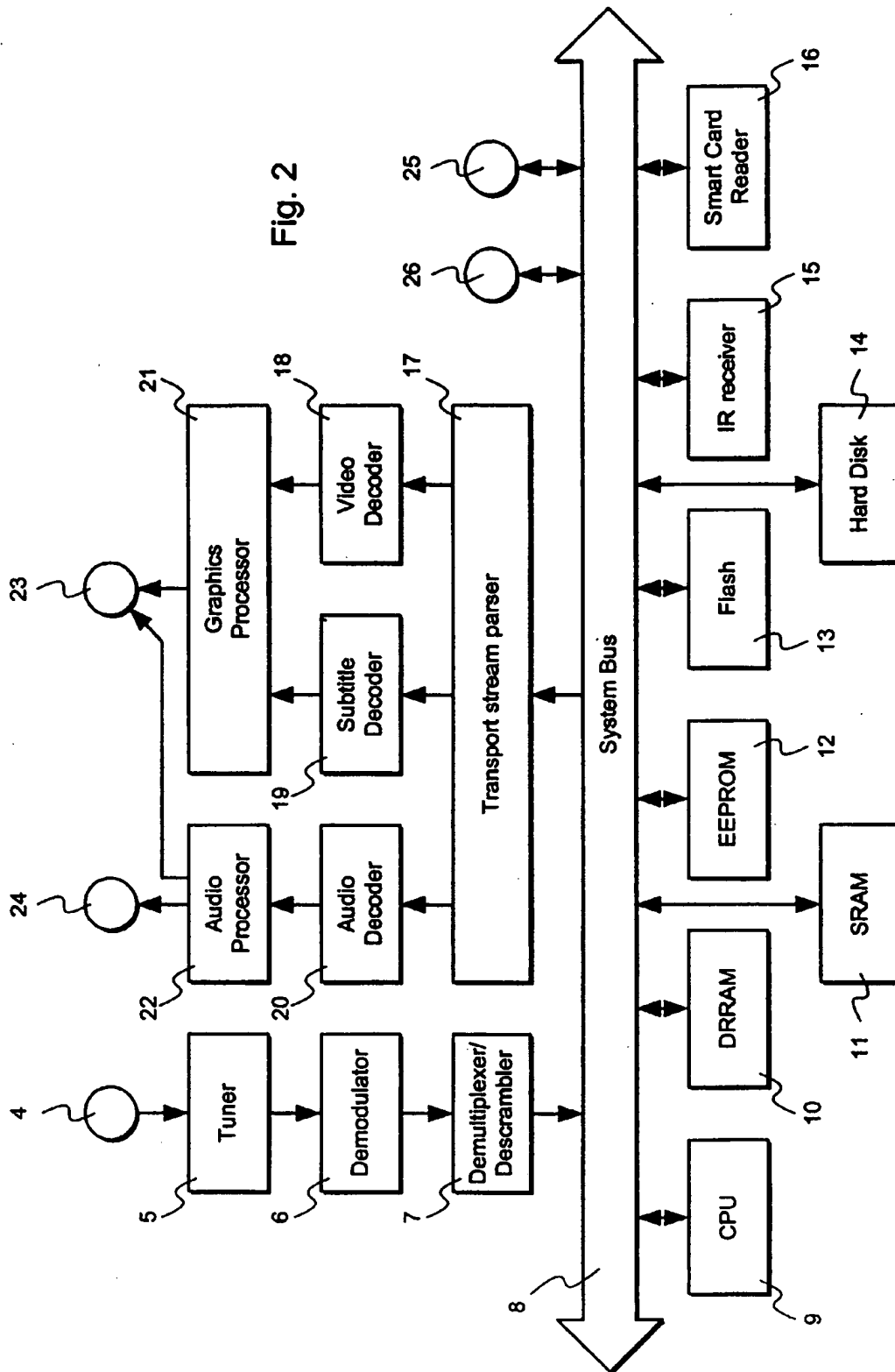


Fig. 3



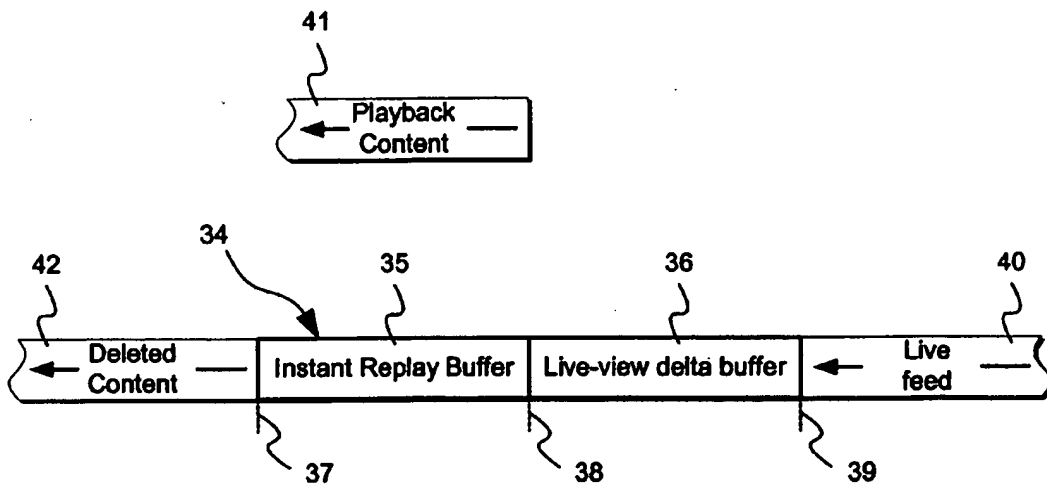


Fig. 4

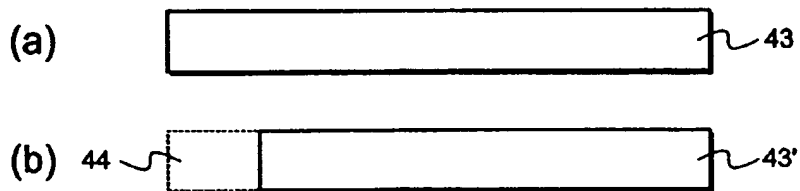


Fig. 5

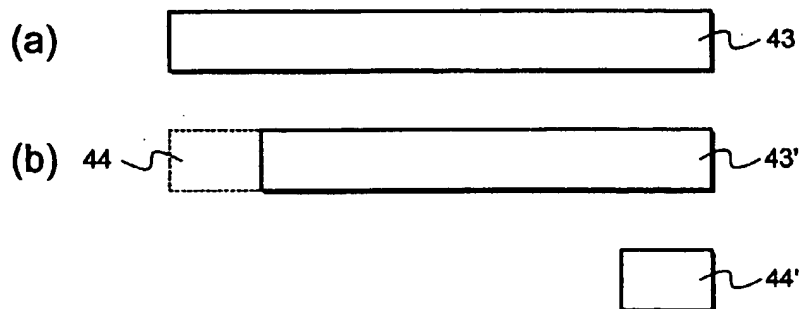


Fig. 6

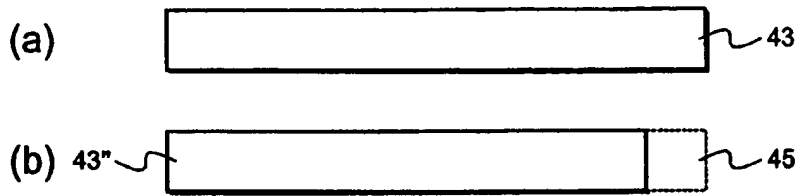


Fig. 7

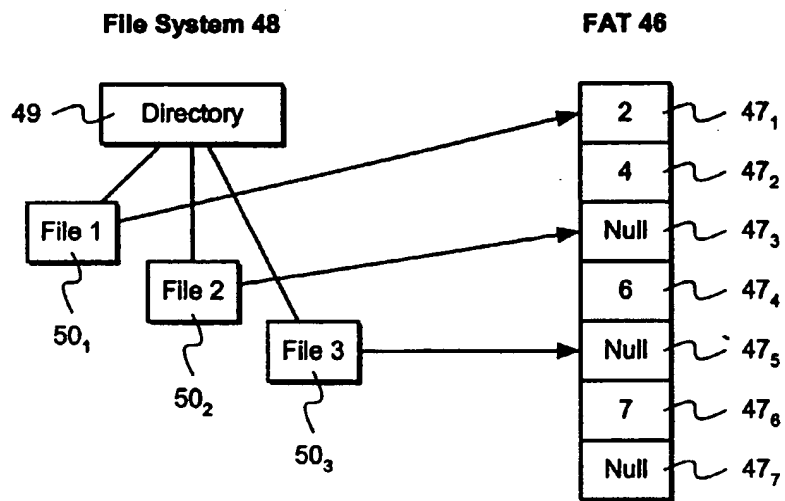


Fig. 8a

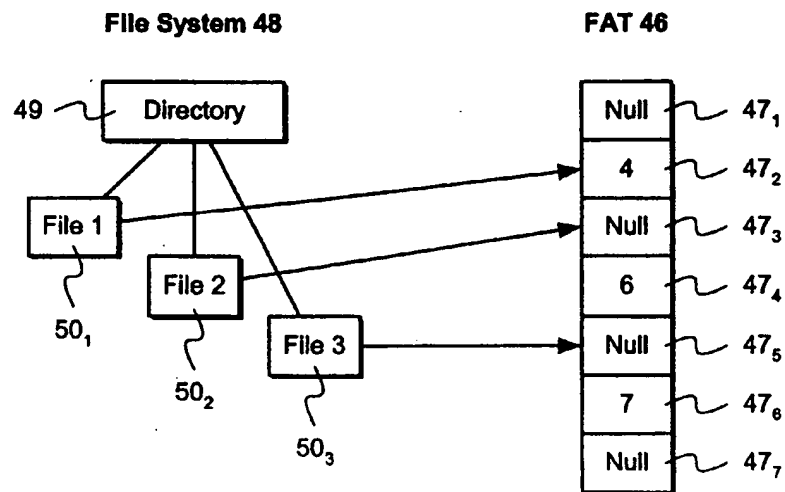


Fig. 8b

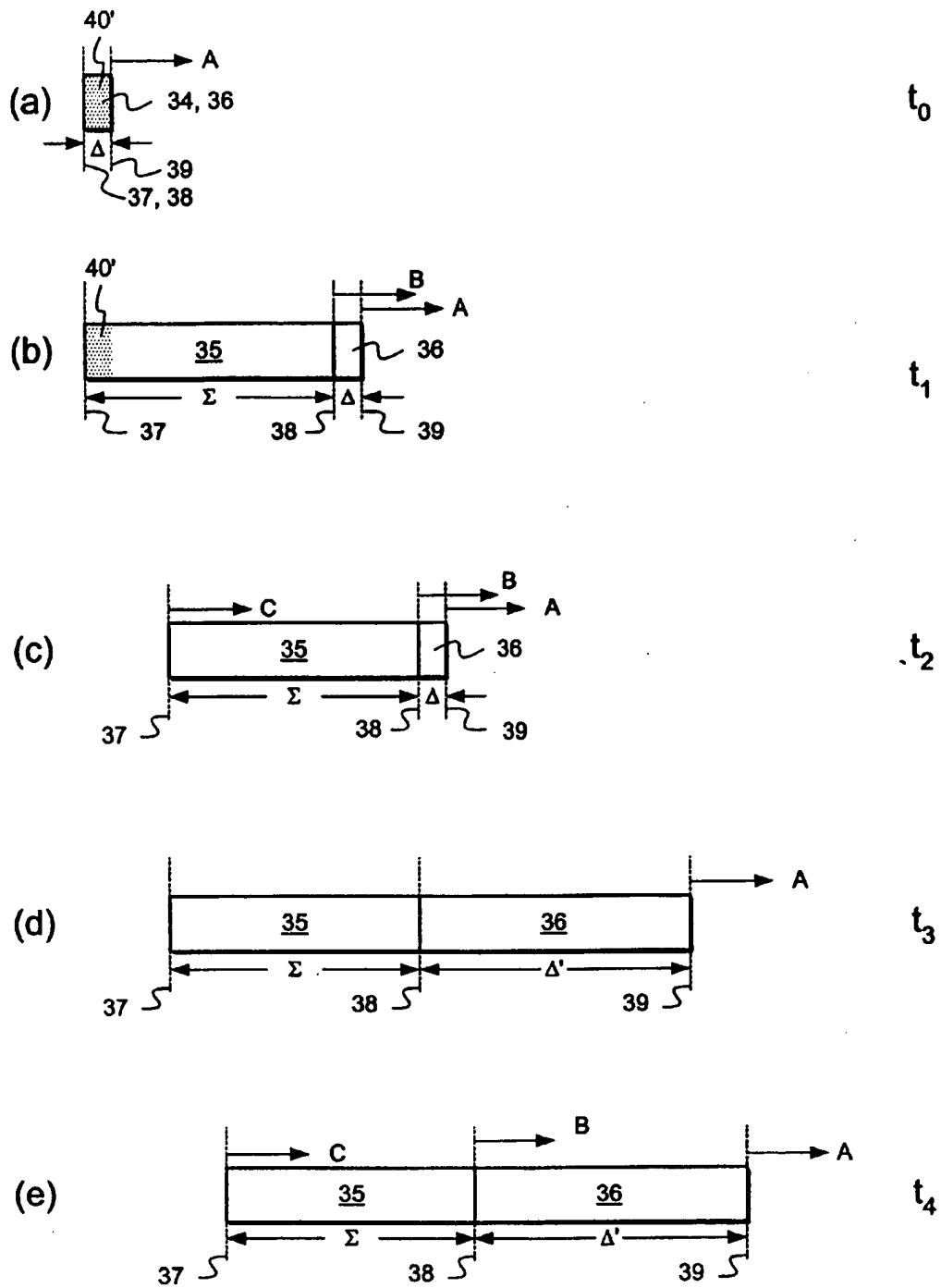


Fig. 9

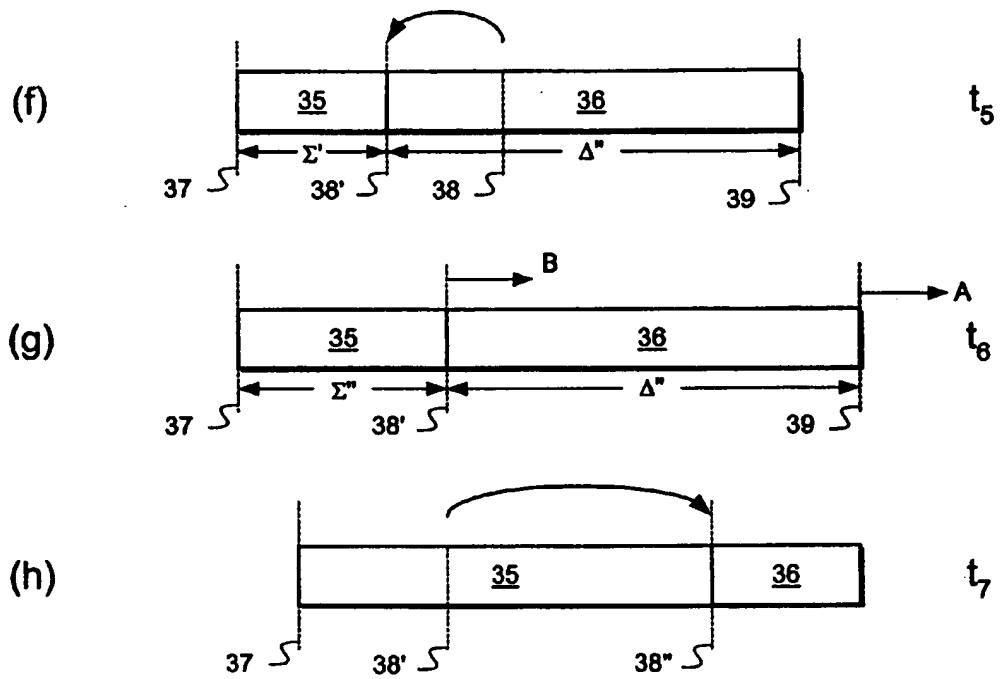


Fig. 9

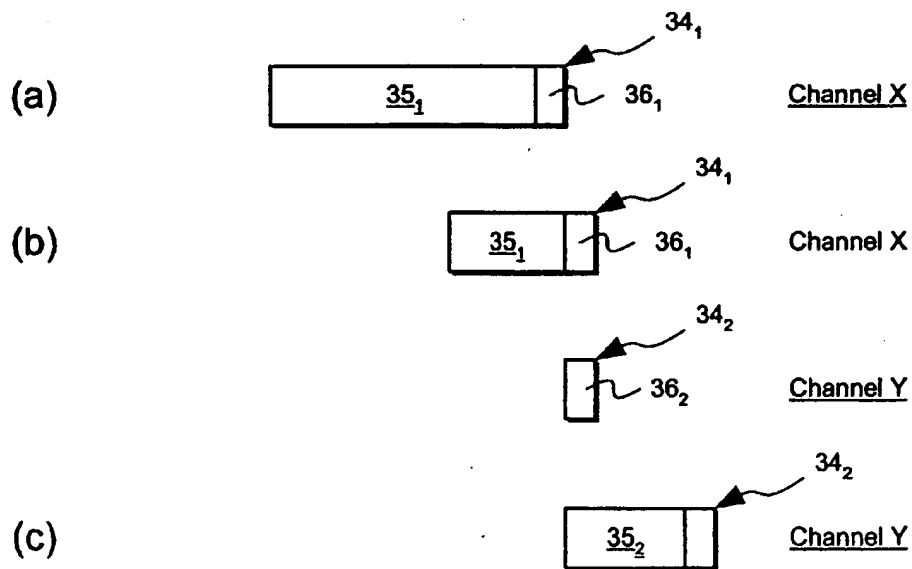


Fig. 10

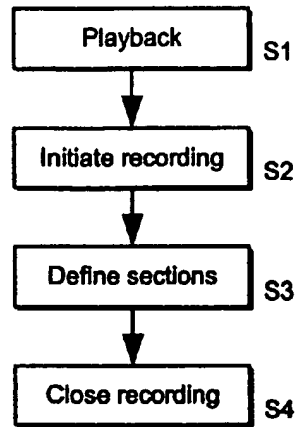


Fig. 11

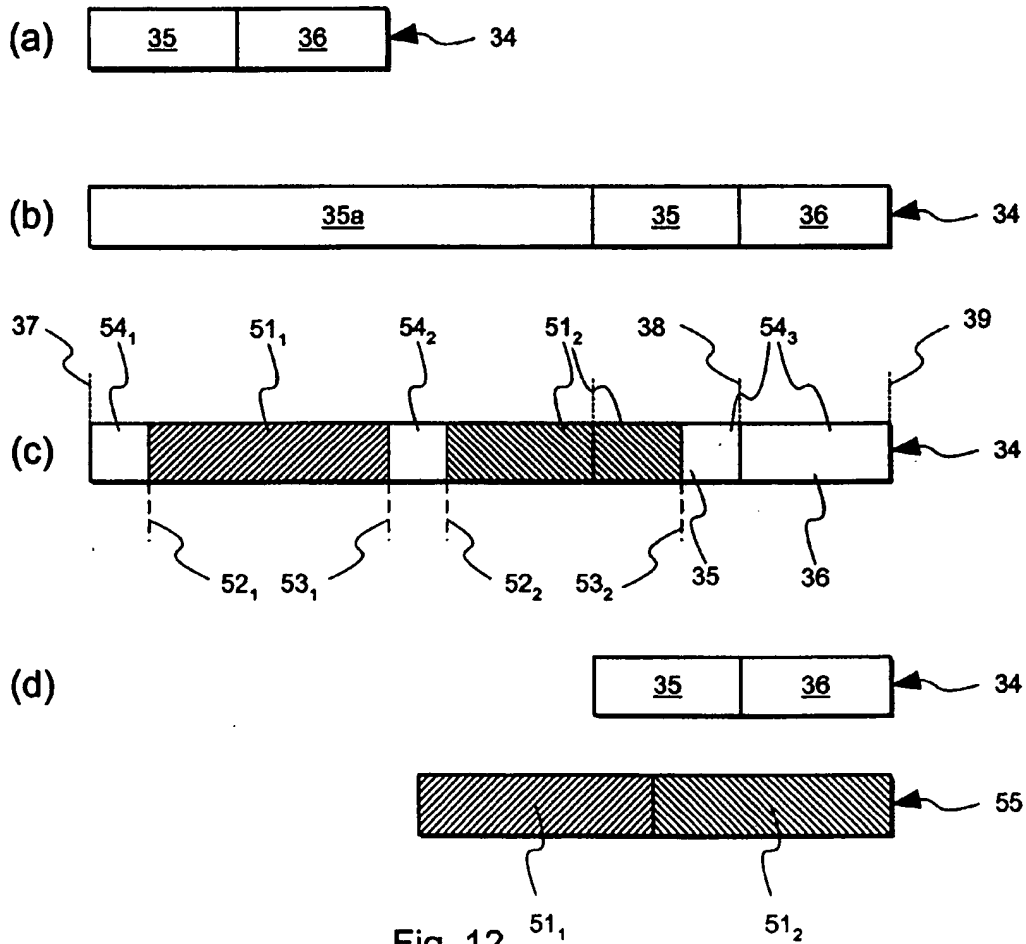


Fig. 12

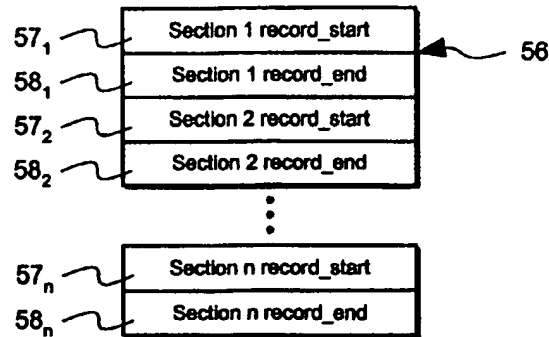


Fig. 13

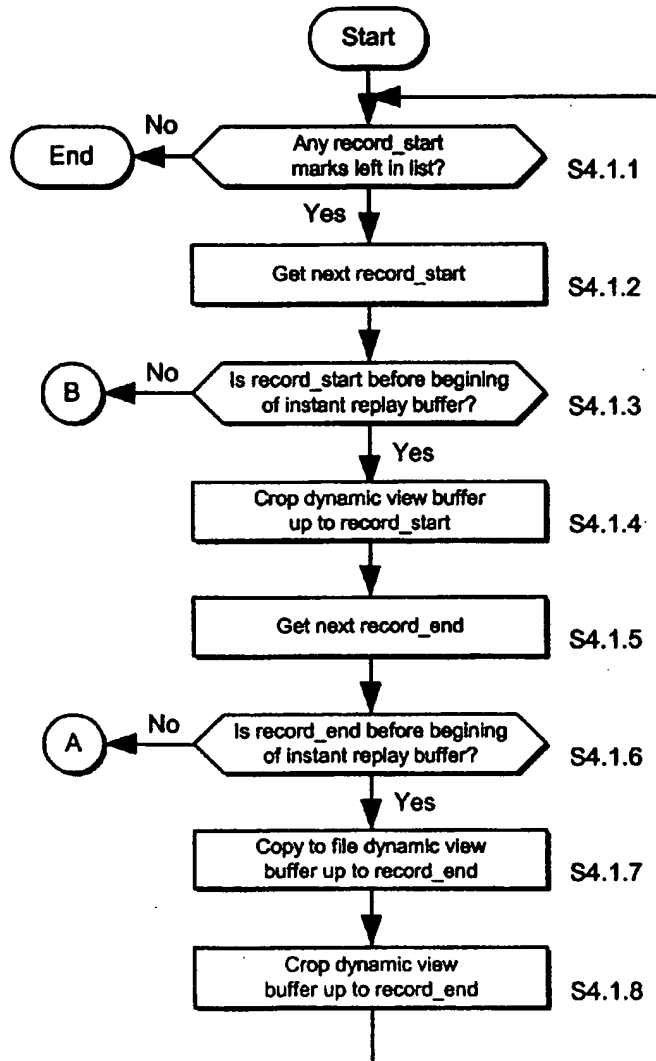


Fig. 14

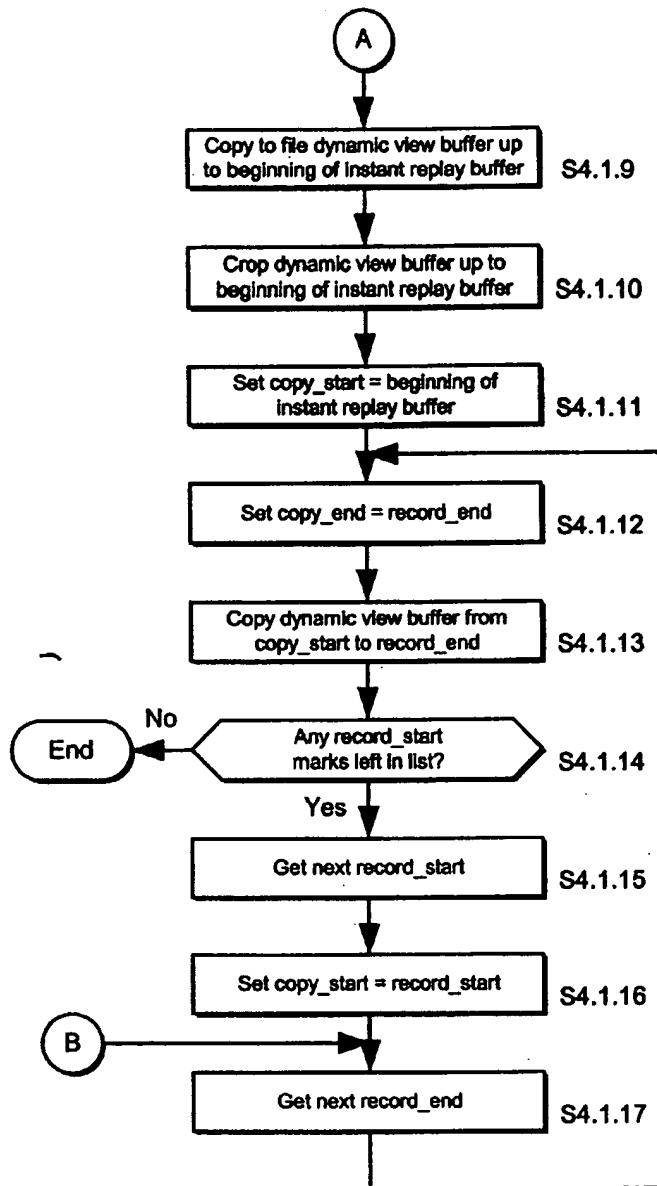


Fig. 14

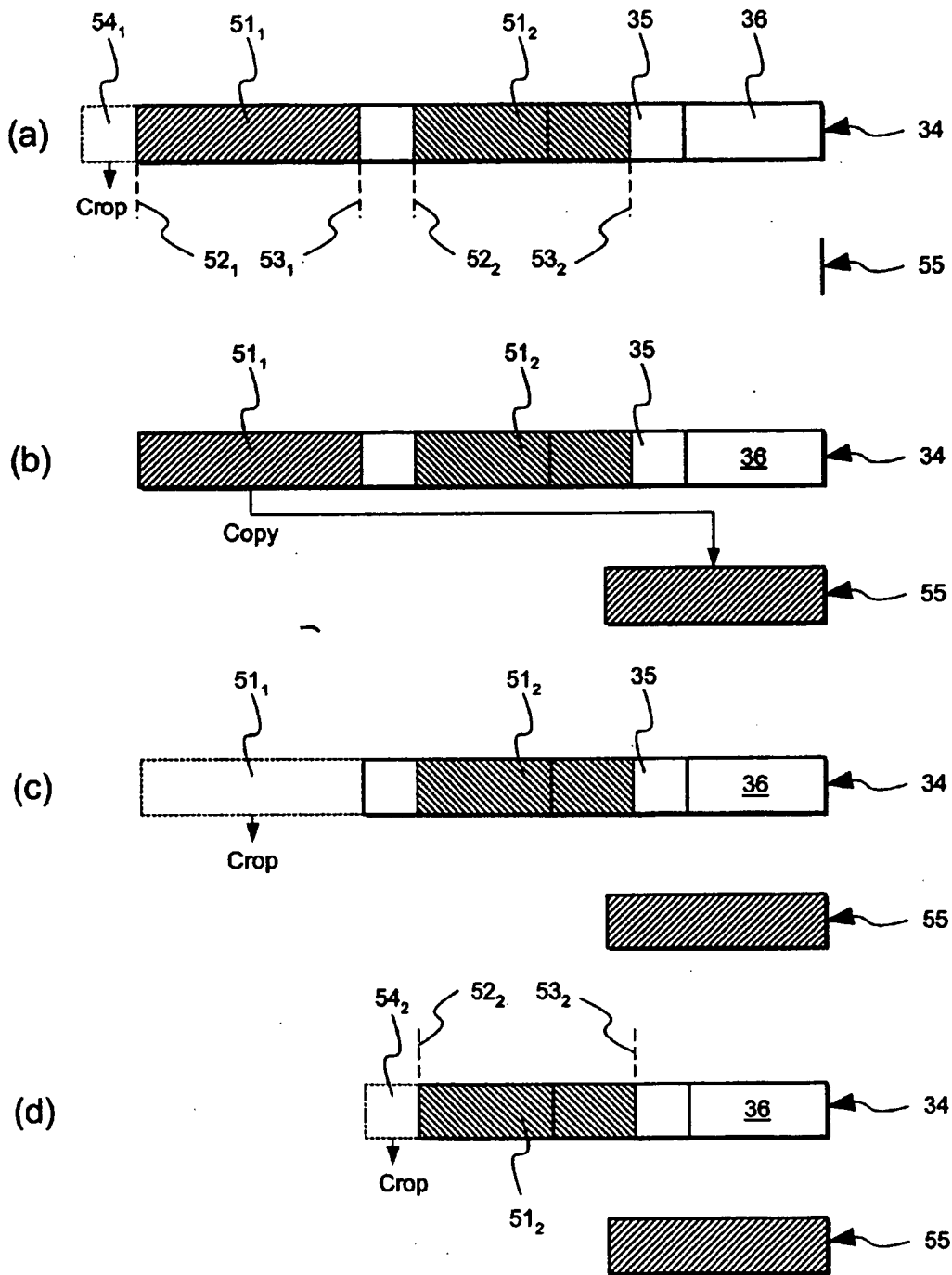


Fig. 15

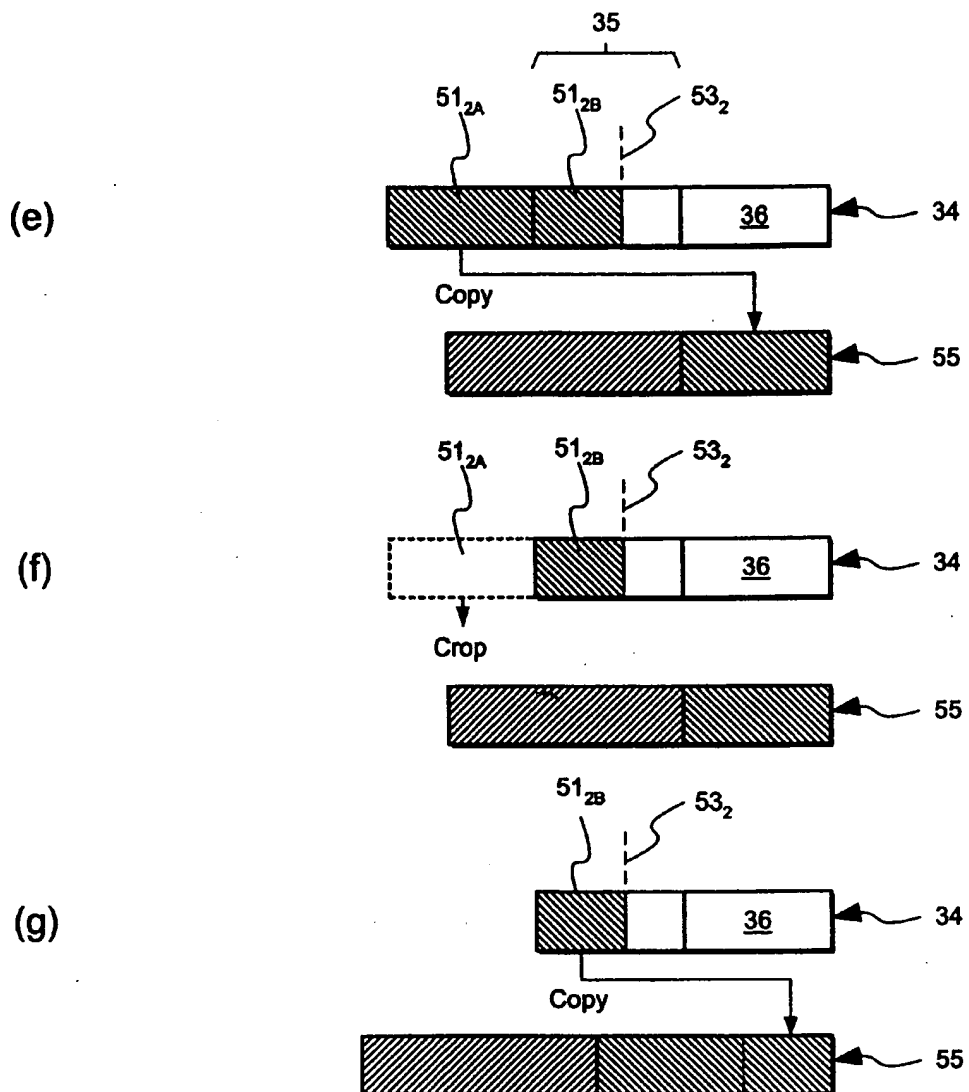


Fig. 15

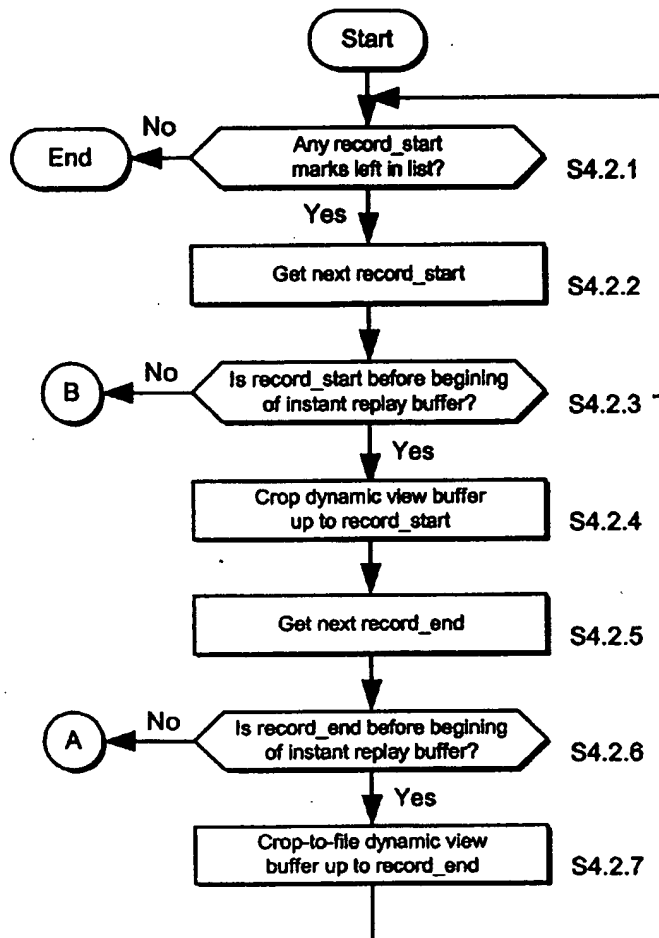


Fig. 16

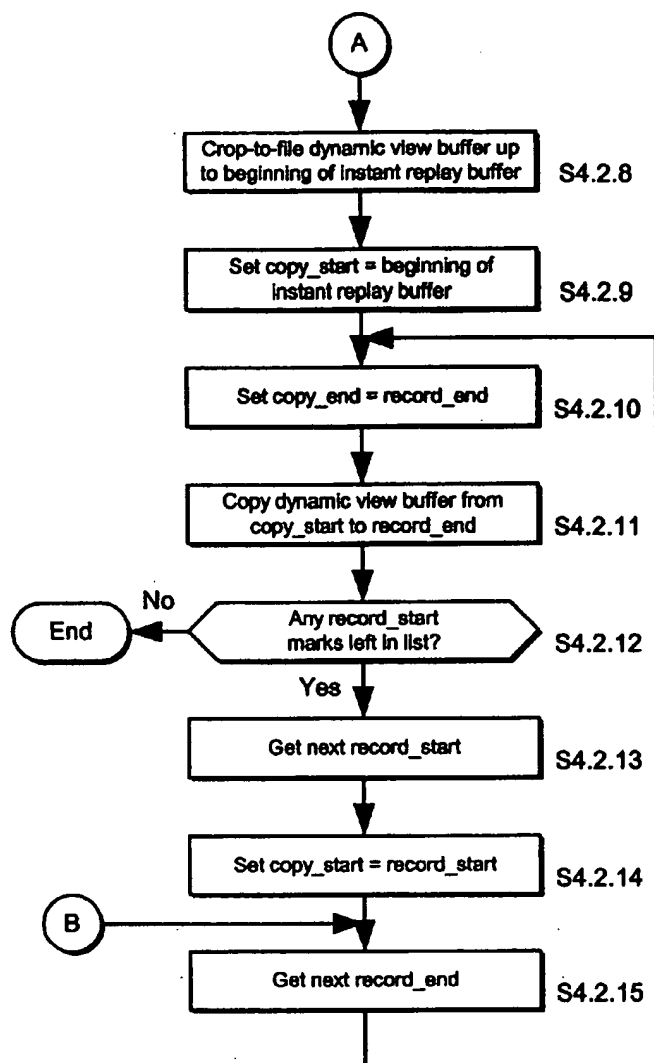


Fig. 16

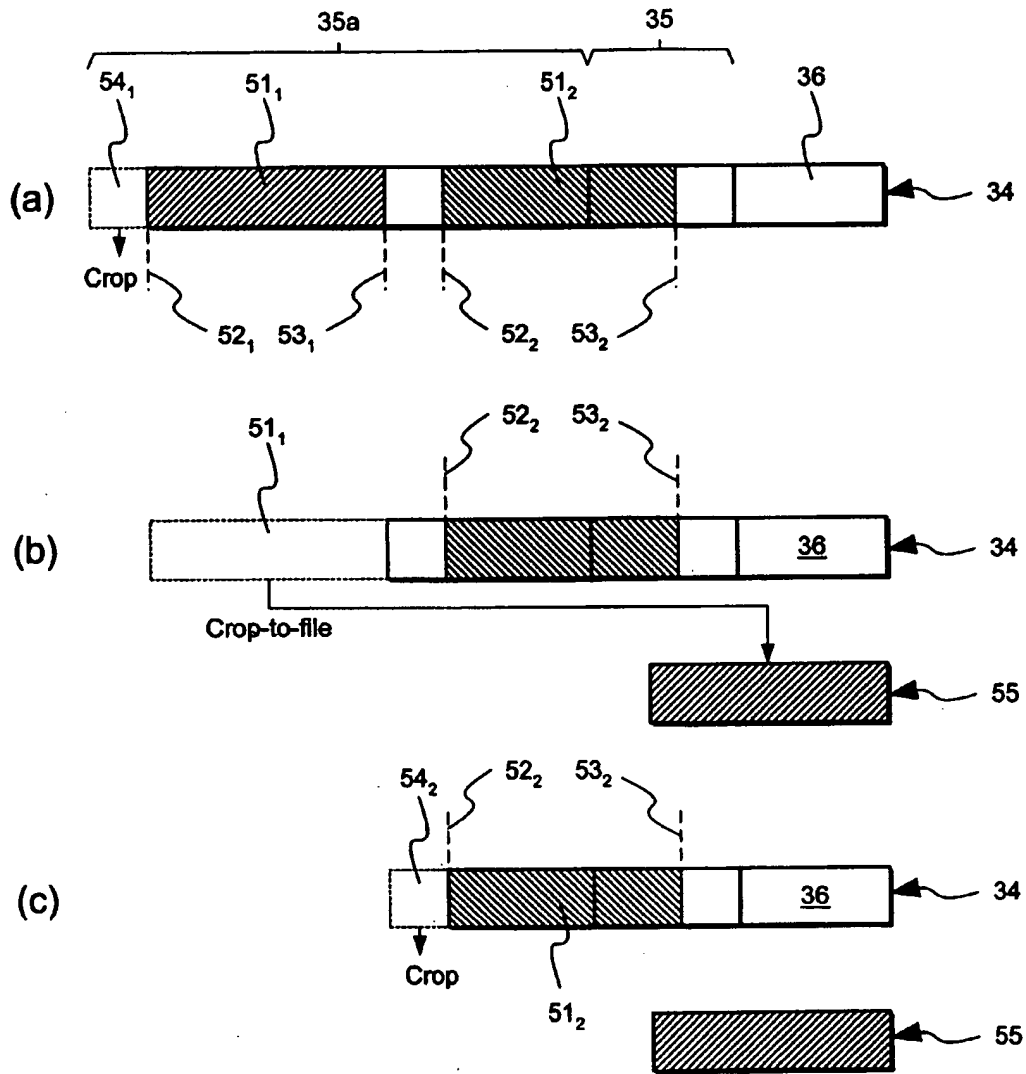


Fig. 17

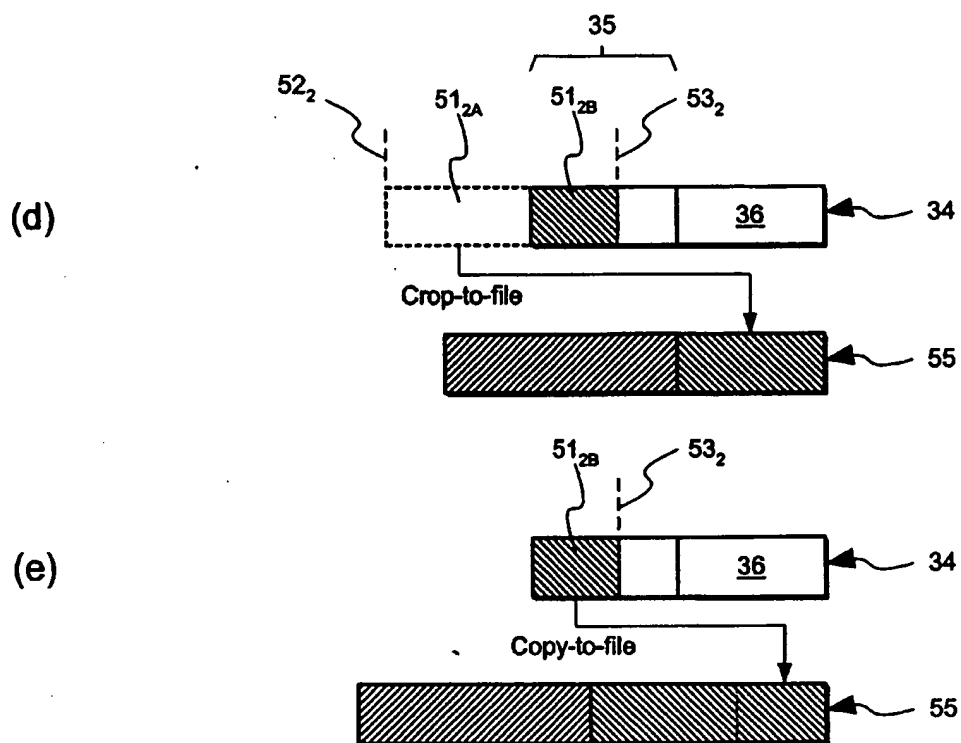


Fig. 17